

*Type locality*.—Guadeloupe, West Indies.

*Type*.—U. S. N. M. No. 52019.

*Host*.—*Leucoptera coffeella* Guér.

Described from 33 females and 17 males (including female type and male allotype) reared from *L. coffeella* by Francisco Sein in July, 1936, on Guadeloupe; and 22 females and 13 males reared by Mr. Sein from the same host, December 7, 1936, on Dominica. Paratypes are deposited in the British Museum and in the University of Puerto Rico.

## TRAP-LIGHT STUDIES ON LEAFHOPPERS BELONGING TO THE GENUS *EMPOASCA* (HOMOPTERA: CICADELLIDAE), WITH THE DESCRIPTION OF TWO NEW SPECIES.<sup>1</sup>

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### INTRODUCTION.

Much has been written in regard to the response of insects to light, whether they are positively or negatively phototropic, and their reaction to lights of different colors and intensities, correlated with the influence of temperature, wind, and various other environmental factors. Many have experimented with the use of trap-lights for attracting insects under these varying conditions. With some species trap-lights seem of importance in ascertaining occurrence and abundance, while with others they appear to have little value. Upon occasion, species which might otherwise be considered rare in a given locality may be procured more readily in this way, possibly by attraction to light or because of nocturnal habits or apparent inactivity during the day. Also, by this means, species new to science have been discovered (7, 9). The general impression, however, seems to be that trap-lights are not of much practical value in the control of insects, although references in the literature to their use, both for exploration of fauna and in insect control, are becoming more frequent (6). The data presented in this paper show that the use of trap-lights in connection with a practical research problem may be of considerable value, especially when correlated with data obtained in other ways.

Two trap-lights were operated over a period of 4 years, 1932-1935, inclusive, at the Arlington Experiment Farm, Arlington, Va., for the purpose of collecting species of leafhoppers belonging to the genus *Empoasca*. The data presented

<sup>1</sup>The writer is greatly indebted to Dr. F. W. Poos, under whose direction this work has been done, and to Mr. P. W. Oman for suggestions and criticisms in the preparation of this paper.

in this paper include the records obtained in the course of these studies on each species, as follows: First and last seasonal appearances, relative abundance, and proportion of sexes. Notes on five new species, with descriptions of two, and some new synonymy are included. The data obtained on the seasonal occurrence of *Empoasca fabae*, the potato leafhopper, an insect of much economic importance, are emphasized, including a discussion of the significance of these data in determining the period of northward migration of this species.

#### EQUIPMENT AND METHODS.

The trap-light used at Arlington was constructed so as to combine the features best adapted for the attraction of smaller insects, such as leafhoppers, with a minimum of loss and damage to them. The apparatus herein described and illustrated (Fig. 1) consists of the following main parts: A metal roof or reflector, a metal funnel, and a glass cyanide jar. The principal measurements of the trap illustrated are as follows: Reflector 30 inches in diameter; funnel 12 inches in diameter and 10 inches in depth; Mason glass jar, 1-quart size, with screw top.

The reflector is made of a fitted circular piece of sheet metal, into the center of which the socket for the electric light bulb is inserted. Midway from the center and equidistant from each other are soldered three large metal hooks, from each of which is suspended a metal chain, about 15 inches long, from which the funnel, with attached jar, is supported at the desired distance from the electric light bulb.

The size and type of electric light bulb are optional. Several different kinds of bulbs were used in these trap-light experiments: 500-watt daylight clear, 500-watt ivory, 200-watt ivory, 200-watt daylight inside frost, and 200-watt daylight blue. While no accurate means was afforded for comparing the effectiveness of these different kinds of bulbs for attracting *Empoasca*, the 200-watt daylight blue bulb seemed to be as effective as any of the other kinds, if not more so, and was therefore used most of the time.

The funnel is made of galvanized iron and is attached to the metal chains, at a distance of about 8 inches from the reflector, by three metal hooks inserted, at equal distances, through its rim. The electric light bulb and top of the funnel are surrounded by  $\frac{1}{4}$ -inch mesh screen wire to prevent the larger insects, especially unwanted Lepidoptera, from entering the funnel. The screw-top of the jar is firmly soldered to the neck of the funnel.

The detachable glass jar serves as the receptacle into which the insects fall and are killed. In it is a preparation of plaster of

paris and cyanide, covered with several layers of blotting paper from which the insects are readily removed.

The whole trap is supported by a stand made of iron pipe—one upright piece, placed firmly in the ground, and an adjustable cross piece from which the light is suspended and through which the electric light cord is run to the socket.

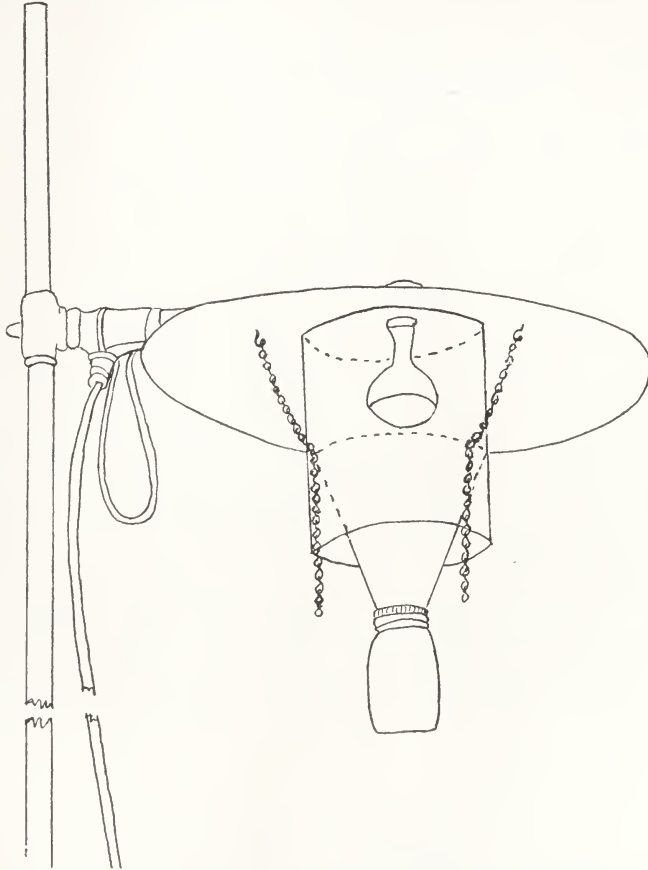


Figure 1.—Trap-light used at Arlington Experiment Farm; *b*, electric bulb; *f*, funnel; *j*, glass jar; *r*, reflector; *s*, screen wire.

The trap-lights were erected in two different locations on the Arlington Experiment Farm and, for convenience, designated A and B. The former was placed so that it would draw largely from the upland territory, mainly from grass, orchard, trees, and shrubs. The latter was located on bottomland, bordering woods on one side and a 65-acre field containing various crops

on its other side. During 1935 no potatoes were grown on the farm, but the field previously mentioned was devoted largely to corn and soybeans, with a variety of other crops such as sugar beets, Jerusalem artichokes, cantaloupes, tomatoes, peanuts, rhubarb, asparagus, and eggplant.

Each season the trap-lights were placed in operation as soon as favorable weather conditions prevailed, the earliest date being April 4, 1935. Both lights continued in operation almost nightly throughout the first season, or until the collections were found to be so heavy as to make quantitative counts impractical. Consequently, in 1933, 1934, and 1935 their use was suspended during most of July and August. Operation of the lights was resumed each season during September, October, and November, the latest date of operation being December 5, 1934, 23 days after the last *Empoasca* had been caught in the traps.

The electric bulb in each light was turned on and off at regular hours, usually at dusk and at dawn. Each day the insect container was emptied and its contents sifted and sorted out. A series of metal sieves, such as are used in separating seeds of different sizes, were found to aid considerably in sorting out smaller leafhoppers from the bulk of miscellaneous material. With the aid of a camel's-hair brush the individual specimens of *Empoasca* were picked out and removed to vials temporarily. All *Empoasca* were saved, and in the smaller collections the sexes were separated under a binocular microscope and counted to determine their relative proportions. In collections totalling 100 or less, all the males were identified to species, and in the larger collections 100 males were selected at random for specific determination.

Since most of the species belonging to this genus can not be definitely differentiated by external morphological characters, a special technic, previously described (*II*), was followed to determine the various species. Preparation of this material for identification was a slow and tedious process, and the accurate determination of the less abundant species required considerable study.

#### COLLECTIONS OF EMPOASCA OVER 4-YEAR PERIOD.

The data obtained from collections of *Empoasca* taken in the two trap-lights during the four seasons 1932, 1933, 1934, and 1935 have been tabulated and summarized in Table 1. These figures were derived from the handling of thousands of specimens of which, as has been stated, only representative numbers were selected for determining the proportion of sexes present and the relative abundance of the various species. Of 27,971 specimens counted, 10,695 were females and 17,276 were males. Among the 11,928 males identified by means of their internal genitalia, 28 different species were represented, 3 of which are still undescribed.

The apparent preponderance of males in 1932 as compared to the more equal numbers of the sexes listed during the other years is due to the fact that in 1932 some of the larger collections (in which males greatly predominated) were counted in toto and these numbers included in the summary. In many of the other large collections only 100 male specimens were sorted out for specific identification, and the proportion of sexes in these collections was, therefore, not determined.

TABLE 1.—SUMMARY OF DETERMINATIONS OF *EMPOASCA* COLLECTED IN TRAP-LIGHTS, ARLINGTON EXPERIMENT FARM, 1932-1935.

Item	1932		1933		1934		1935		Total
	Trap A	Trap B	Trap A	Trap B	Trap A	Trap B	Trap A	Trap B	
Earliest collection:									
Females.....	Date	Date	Date	Date	Date	Date	Date	Date	
Males.....	5/16 <sup>1</sup>	6/6 <sup>1</sup>	5/13	5/15	5/11	5/11	5/7	5/7	
	5/20	6/6	5/13	5/15	5/12	5/14	5/7	5/10	
Latest collection:									
Females.....	11/10	11/6	11/5	11/2	11/29	11/19	11/11	11/12	
Males.....	11/10	11/6	11/3	11/2	11/21	11/4	11/12	11/12	
Proportion of sexes: <sup>2</sup>	Number	Number	Number	Number	Number	Number	Number	Number	Number
Females.....	1,341	1,261	1,356	1,554	1,589	1,055	1,413	1,126	10,695
Males.....	3,957	3,011	1,520	1,675	1,601	1,319	2,455	1,738	17,276
Males determined as to species:									
<i>Jabae</i> .....	1,234	549	1,271	1,254	1,315	901	2,230	1,348	10,102
<i>erigeron</i> .....	77	138	42	207	98	237	115	192	1,106
<i>pergandei</i> .....	4	5	2	98	3	7	2	68	189
<i>solana</i> .....	1	7	15	11	23	59	11	15	142
<i>sativa</i> .....	1	0	30	6	29	2	0	0	68
<i>recurvata</i> .....	5	14	0	18	6	10	2	2	57
<i>alboneura</i> .....	30	1	9	1	2	0	1	1	45
<i>bijurcata</i> .....	4	2	5	5	6	10	5	5	42
<i>birdii</i> .....	0	1	0	5	12	7	3	7	35
<i>salicis</i> .....	0	10	1	15	0	2	0	5	33
<i>atrolabes</i> .....	0	1	0	25	0	3	0	1	3
<i>obtusa</i> .....	10	1	3	1	1	2	1	0	19
<i>patula</i> .....	0	3	1	0	0	1	1	7	30
<i>dentata</i> .....	0	4	0	4	1	0	0	0	9
<i>ditata</i> .....	0	2	0	2	3	0	0	1	8
<i>chelata</i> .....	0	0	1	5	0	0	1	0	7
<i>delongi</i> .....	0	0	2	4	0	0	0	0	6
<i>maligna</i> .....	0	4	0	0	0	0	0	0	4
<i>curvata</i> .....	0	0	0	0	1	1	0	0	2
<i>incipida</i> .....	0	0	0	1	0	1	0	0	2
<i>unica</i> .....	0	1	1	0	0	0	0	0	2
<i>pallida</i> .....	0	1	0	0	0	0	0	0	1
<i>smaragula</i> .....	0	0	0	1	0	0	0	0	1
<i>vergena</i> .....	0	0	0	0	0	1	0	0	1
<i>ellisiae</i> .....	0	0	0	0	0	0	0	1	1
Undescribed.....	0	0	0	1	0	0	1	1	3
Total.....	1,366	744	1,383	1,664	1,500	1,244	2,373	1,654	11,928

<sup>1</sup> In 1932, trap-light A was not operated until May 16, and B not until June 6.

<sup>2</sup> See discussion, page 146.

## VARIATION IN THE PROPORTION OF SEXES.

Females were seasonally among the very first specimens of *Empoasca* to be caught in the trap-lights. In four instances out of eight both sexes appeared in the first collections, and in the other four instances females were caught from 1 to 4 days earlier than males. During the first week or ten days after the first specimens were caught the trap-light collections generally remained very small, the number of females usually exceeding that of the males. Likewise, in collections made by sweeping in the field with an insect net during this same period, females were the first to be obtained and they occurred in much greater proportion than males. As the season advanced the collections gradually grew larger. As the numbers of *Empoasca* increased at the trap-lights, the proportion of males increased, until in the larger collections they far outnumbered the females. During the period of greatest abundance approximately 75 percent of the adults in the collections at the trap-lights were males, whereas this proportion of sexes was almost exactly reversed in collections made during the same period with the net in the field, 75 percent of the adults being females. During July and August trap-light collections proved heaviest, with a perceptible falling off in numbers as soon as the nights grew cooler. In the comparatively small collections made during September, October, and early November each year the number of males and females became more equal, a few individuals of each sex being taken in the last collections. The latest date for a female to be caught in the trap-light was November 29, 1934, and for a male November 21, 1934, both of those in trap A.

## NUMBER OF DIFFERENT SPECIES OF EMPOASCA ATTRACTED.

The collections obtained from the trap-lights have shown that not only a larger quantity but a much greater variety of *Empoasca* have been obtained than with an equal amount of effort put forth in collecting by sweeping various host plants with insect nets. As has been stated, the total number of species obtained during the four seasons was 28, including 3 species still undescribed, but the greatest variety of species to be collected in one season numbered 17, taken both in 1932 and in 1933 at trap-light B. It may be noted that during all the seasons under observation a greater variety of species of *Empoasca* was obtained from trap-light B, where there was apparently a greater variety of hosts nearby from which to draw. It is significant also, that in this trap, located in the lowland, where there was probably a greater variety in host material, the total number of *Empoasca fabae* was less each year than in trap A, located in the upland.

The greatest variety of species each season was collected

during June and September, the maximum number in one collection being 10, taken September 25, 1933. Nine species were taken in one collection June 20, 1932, seven species September 26, 1934, and six species June 11, 1935.

The two species of *Empoasca* most commonly present in the trap-lights were *fabae* and *erigeron*. They occurred in the trap-lights throughout the entire season, while the species less common showed more definite seasonal appearance. The following species, in the order of their abundance, were taken in both the spring and the fall collections, although in some cases they were more abundant in the spring: *pergandei*, *alboneura*, *bifurcata*, *birdii*, *salicis*, *patula*, *ditata*, *incida*, and *unica*. The species *atrolabes*, *obtusa*, *maligna*, *curvata*, *pallida*, *smaragdula*, and *vergena* were collected only in the spring, while *solana*, *sativae*, *delongi*, *chelata*, and *ellisae* were collected only in the fall. *Empoasca recurvata* and *E. dentata* were taken both in the spring and in the fall, although more specimens of each species were found in the fall collections. Two of the undescribed species were taken in the spring and one in the fall.

As indicated by collections in the field, *Empoasca fabae* is by far the most abundant species. From the 11,928 specific determinations made from internal male genitalia, 10,102 were of *fabae*, 1,106 of *erigeron*, 189 of *pergandei*, and 142 of *solana*. The other 24 species taken in the trap-lights were represented by less than 100 specimens each, and in 7 of these species only a single male specimen was procured. By this means the following species, not previously obtained by sweeping in the field, were collected for the first time in this locality: *atrolabes*, *obtusa*, *patula*, *incida*, *chelata*, *unica*, *pallida*, *ellisae*, and three undescribed species.

These trap-lights have also yielded what appear to be the earliest records on the occurrence of some species of *Empoasca* which at the time were recognized as species new to science, but have since been described from later collections from other sources. *Empoasca chelata*, recently described by DeLong and Davidson (5) from two specimens, male and female, collected at Okolona, Miss., June 14, 1934, from *Crataegus*, was collected in the trap-lights at Arlington Farm for the first time September 19, 1933, six male specimens being taken during the period September 19 to October 1. Likewise, *E. ditata*, described by DeLong and Caldwell (4) from two male specimens collected at Cedar Swamp, Ohio, April 17 and 24, 1934, are represented in the Arlington Experiment Farm trap-light collections by eight specimens collected as early as June 21, 1932.

#### NEW AND UNDESCRIBED SPECIES.

The three specimens of *Empoasca* listed in the table as undescribed represent, in the writer's opinion, three distinct new

species. However, in each case neither the external characters nor the internal male genital characters are distinct enough to justify the description of a new species from a single individual, and they are, therefore, retained in *statu quo* until a larger series may be procured. Another single specimen, however, with well-defined internal male genital characters, is recognized as a species new to science and its description and that of another new species, described from a series of eleven males, follow:

**Empoasca ellisae**, new species.

A medium-sized species of yellowish-green color. Length about 3 mm.

*External characters*.—Face tinged with orange. Vertex yellowish green with touches of orange on either side of median line; broad, rounded, but not parallel margined, produced about one-third its length beyond anterior margins of the eyes, about twice as wide between eyes as length at middle. Pronotum with prominent humeral angles tinged with bluish green; about as wide as head and more than twice as long. Scutellum with an irregular pale longitudinal median band terminating near the apex in a small circular spot. Elytra long, yellowish green, with apical third hyaline.

*Male internal structures* (Fig. 2).—Lateral processes long, slender, and bluntly tapered in lateral view; in ventral view nearly straight, widening gradually toward tips and ending in a small, slightly curved projection on the inner margins. Dorsal spines heavy and tapering to sharp points; in lateral view long and strongly curved, first caudad, then ventrad and cephalad with their apices directed anteriorly. Styles relatively broad and long; in ventral view, inner margins more or less regular and parallel along middle third, but curved outwards at apical third, which is more heavily chitinized, with apices divergent; outer margins sinuate.

Sternal apodemes relatively short, about as broad as long, with posterior ends slightly rounded and divergent.

Described from one specimen taken in trap-light B, Arlington Experiment Farm, Arlington, Va., November 5, 1935.

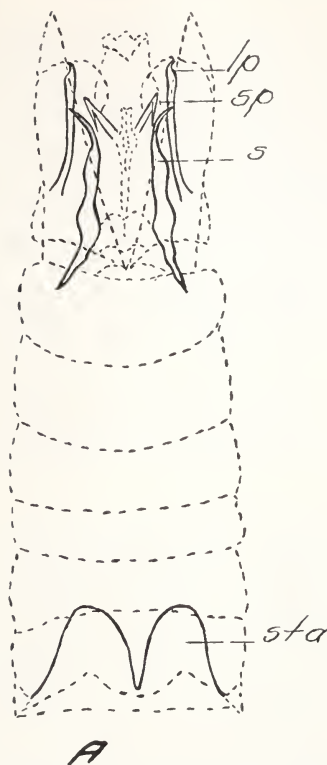
Holotype male in United States National Museum collection (Cat. No. 52011).

**Empoasca salicis**, new species.

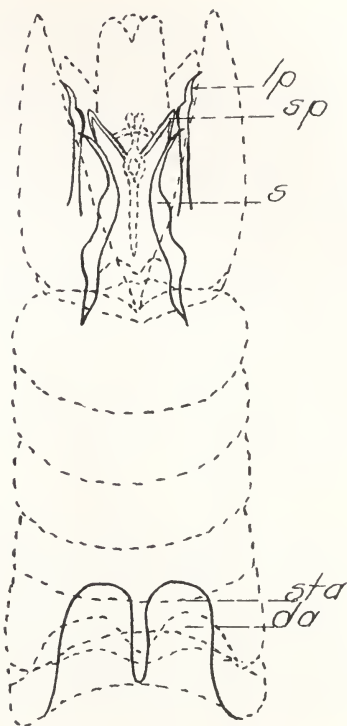
Resembles *patula* in form, but darker in color with both dorsal and sternal apodemes, the latter being very much shorter and narrower than those of *patula*. Length about 3.5 to 4 mm.

*External characters*.—Face greenish yellow. Vertex and upper portion of clypeus tinged with orange; vertical median area and narrow margins adjacent to eyes white. Pronotum brownish yellow with three white spots near anterior margin; humeral angles tinged with green. Scutellum with an irregular longitudinal median white stripe. Elytra long, greenish yellow in color with apices tinged with brown, hyaline; narrow black line along inner margin and extending around apices.

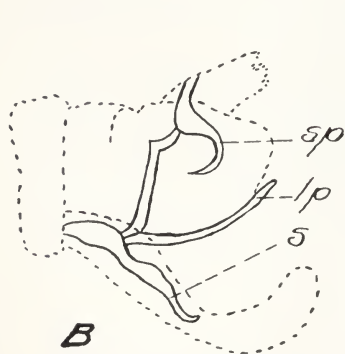




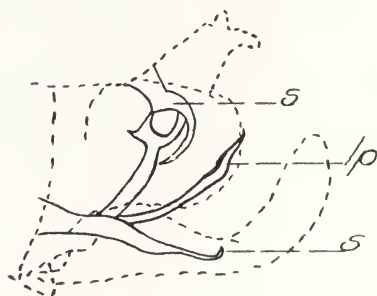
A



*ellisae*  
Fig. 2



B



*salicis*  
Fig. 3

Figure 2.—Internal structures of abdomen of male of *Empoasca ellisae*, n. sp.: A, ventral view; B, lateral view; lp, lateral process of pygofer; s, style; sp, dorsal spine of tenth segment, sta, sternal apodeme for muscular attachment.

Figure 3.—Internal structures of abdomen of male of *Empoasca salicis*, n. sp.: A, ventral view; B, lateral view; lp, lateral process of pygofer; s, style; sp, dorsal spine of tenth segment; sta, sternal apodeme for muscular attachment ba, dorsal apodeme.

*Male internal structures* (Fig. 3).—Plates in lateral view long, wide at base, narrowed toward middle, abruptly curved upward with apex rounded; heavily clothed ventrally with long spines. Lateral processes long, slender, slightly curved upward in lateral view, somewhat enlarged near apical third, then tapering and sinuate; in ventral view long, slender, with basal two-thirds comparatively straight, slightly enlarged near apex with elongated, fingerlike process curved outwardly on outer margin. Dorsal spines heavy, elongated, and tapering to points, in lateral view wide at base and gradually tapering, curving first caudad, then ventrad and cephalad, with apices directed anteriorly. Styles relatively long and heavy; in ventral view basal two-thirds broad with outer margin more sinuate than the inner, slightly convergent toward middle with apical third curved outwardly, and their pointed apices widely divergent; in lateral view relatively broad at base, narrowing toward apical third, with tip abruptly curved upward.

Sternal apodemes relatively short, about one and one-half times as long as broad, with margins almost parallel and posterior ends broadly rounded. Dorsal apodemes less pronounced, about one-third as long as sternal apodemes and slightly broader.

Described from eleven males taken in trap-lights A and B, Arlington Experiment Farm, Arlington, Virginia, during May and June, 1933. This species was also reared at Arlington Experiment Farm from nymphs collected on willow in 1931.

Type male in United States National Museum collection (Cat. No. 52041). Paratype males in United States National Museum collection and in the collection at entomological laboratory, Arlington Experiment Farm.

#### NEW SYNONYMY RESULTING FROM STUDY OF EMPOASCA FROM TRAP-LIGHT MATERIAL.

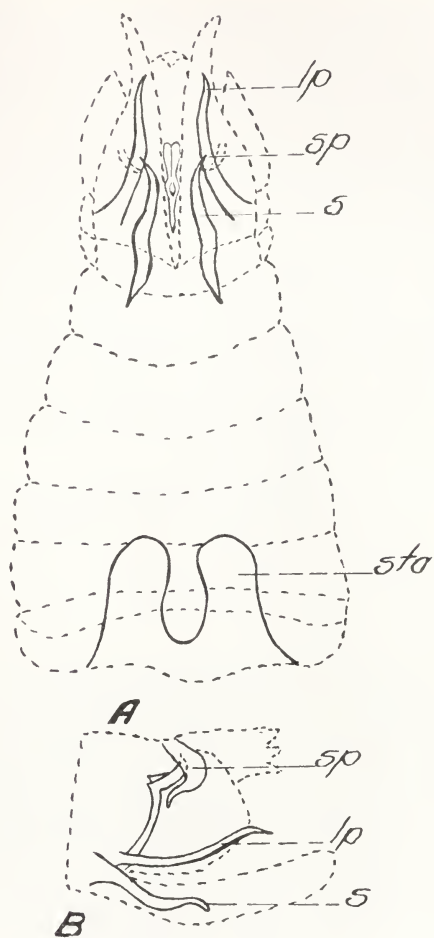
Several species of *Empoasca* whose identities have been somewhat confused have been collected in the trap-lights, and in order to list them properly an effort has been made to determine their exact status. Through the helpful cooperation of Mr. P. W. Oman, Division of Insect Identification, Bureau of Entomology and Plant Quarantine, *Empoasca* material from the Arlington Experiment Farm trap-lights has been compared with certain type material in the United States National Museum. The new synonymy that follows has resulted from these investigations.

#### *Empoasca birdii* Goding.

*Empoasca birdii* Goding, Ent. News 1: 123-124, 1890.

*Empoasca infusca* DeLong, Ohio Jour. Sci. 32: 398-399, 1932 (new synonymy).

Goding's description of this species, made from external characters only, might apply equally well to a great many



*vergena*

Figure 4.—Internal structures of abdomen of male of *Empoasca vergena* DeL. and Cald.: *A*, ventral view; *B*, lateral view; *lp*, lateral process of pygofer; *s*, style; *sp*, dorsal spine of tenth segment; *sta*, sternal apodeme for muscular attachment.

species of the genus. Because of this, it was considered necessary to look for the type material of this species and to make the identification from that now extant. Therefore, in the search for type material in the National Museum a single male specimen having the necessary data as to locality, date, etc., to be considered one of the type series, was located by Mr. Oman. The internal structures were found to differ from those figured by DeLong (2) for *birdii*, but were identical with those described and figured later by him for *infusca*. *Empoasca infusca* is therefore placed as a synonym of *E. birdii* Goding; the specimen labeled "on corn and apple, from F. W. Goding, Rutland, Ill., Nov., 1889," is here designated lectotype of *E. birdii* Goding. As stated by DeLong (3) in his description of *infusca*, superficially that species, *birdii*, and *vincula* can not be distinguished, but on the basis of the genital characters they are easily separated. The species treated by DeLong in 1931 as *birdii* appears to be identical with that later described by DeLong and Caldwell (4) in 1934 as *vergena*.

*Empoasca birdii* Goding is represented in the Arlington Experiment Farm trap-light collections by 35 specimens.

***Empoasca vergena* DeLong and Caldwell.**

*Empoasca birdii* DeLong (nec. Goding, 1890), U. S. Dept. Agr. Tech. Bull. 231: 38, 1931.

In their description of *vergena* DeLong and Caldwell (4) state that it resembles *infusca* (which equals *birdii* Goding) in size and coloration. The recognition of the superficial resemblance of *birdii* Goding, *birdii* as identified by DeLong, and *vincula* has already been pointed out. On the basis of genital characters, it would at first seem, from a comparison of the illustration of the species identified by DeLong as *birdii* with the illustration of *vergena* by DeLong and Caldwell, that there is a structural difference between the two. However, in a study of the internal genitalia from a series of both reared and field-collected material at Arlington Experiment Farm, a variation is noted that would explain this difference and would justify the conclusion that these are one species. In the series of reared specimens (male offspring from the same female, obtained in connection with life-history studies) there is a slight variation in the lateral processes of the pygofer, ranging from "almost straight," as in the species identified by DeLong as *birdii*, to "pointed forcep-like apices," as figured by DeLong and Caldwell for *vergena*. Variation in the contour of the lateral pygofer processes is not uncommon in a species of this group and has been frequently observed in the study of a number of specimens of the very common species *fabae*. In *vergena* there seems to be no variation in any of the other internal characters. As

further evidence of the close relation of this series, outside of the one specimen collected in the trap-light, all of the other specimens studied (23 in number) were either reared or collected upon the same host, nettle (*Urtica gracilis* Ait.), and of those collected eleven were taken upon the same date. Also, from females of this reared material, which was then designated as the species identified by DeLong as *birdii*, Balduf (*l*) studied the ovipositors and illustrated the valvular structures which he found furnished characters quite adequate to distinguish the species.

To show the more nearly typical structure in the lateral pygofer processes, the species is re-illustrated (Fig. 4) from a male specimen representing neither extreme, but a modification of these characters. The sternal apodemes are illustrated also, since they offer distinctive and constant structural characters.

*Empoasca birdii* DeLong (nec. Goding) is therefore placed as a synonym of *E. vergena* DeLong and Caldwell.

#### ***Empoasca pallida* Gillette.**

*Empoasca pallida* Gillette, Proc. U. S. Nat. Mus. 20: 741, 1898.

*Empoasca constricta* DeL. and Dav., Ohio Jour. Sci. 35: 31, 1935 (new synonymy).

Gillette described *pallida* from 5 females and 2 males labeled "cotton, N. Car., June, '79." At the present time the type series in the National Museum contains 6 adults, including 1 male, and all but 1 female bearing U. S. N. M. Type No. 3435. DeLong (*2*) pointed out that the type series was a mixed one, and apparently concluded that the particular female bearing Gillette's name label *pallida* represented the species *birdii* DeLong (nec. Goding, 1890). Because of the difficulty, or in some cases the impossibility, of recognizing definitely the females of many species of *Empoasca*, it seems best to place *pallida* Gillette on the basis of the male type, which agrees completely in external characters with the female bearing Gillette's label. This male type, when prepared for study of the internal structures by Mr. Oman, was found to be quite distinct from *birdii* as characterized by DeLong in 1931. The internal male characters are found, however, to be identical with those of *constricta* as later described and illustrated by DeLong and Davidson. *Empoasca constricta* is therefore placed as a synonym of *E. pallida*.

One specimen of this species was taken in trap-light B, June 20, 1932.

#### SEASONAL OCCURRENCE OF *Empoasca fabae*.

*Empoasca fabae* was the first and the last species as well as by far the most abundant, to be collected in the trap-lights

each year. This species was first collected in the trap-lights in the spring during the period May 7 to 15, the same period during which *E. fabae* was first taken in the field each season for several years by sweeping alfalfa and other host plants with insect nets. The earliest record (8) for the appearance of adults of *E. fabae* from sweeping in the field at Arlington Experiment Farm was May 10, 1929, when fertile females, collected for life-history cages, produced male offspring identified as *E. fabae*. The earliest date of its appearance in the trap-lights (verified by the determination of males only) was May 7, 1935, when 6 females and 11 males (all *E. fabae*) were caught at trap-light A, after the lights had been in operation since April 2. This was 4 days earlier than the records of previous years for the first appearance in the trap-lights of this or any other *Empoasca* species and may be correlated with the fact that very strong warm southwest winds prevailed May 5 to 7.

In 1934 another interesting record was obtained on the early appearance of *Empoasca fabae*. Both trap-lights had been running since May 6, but nothing was obtained until the night of May 11, when 6 females were caught in trap A and 4 in trap B. The previous day, May 10, there was a strong, warm wind, followed by a dust storm and a thunder storm. The traps were not emptied May 12, but on May 13, in trap-light A there were 353 females and 24 males of the genus *Empoasca* and in trap-light B 6 females and no males. The collection in trap A was phenomenally large for so early in the season, and, correlated with the prevailing weather conditions, would indicate a possible migration from a more southerly location. Identification of the males from this collection yielded 23 *E. fabae* and 1 *E. curvata*, a recently described and rather uncommon species in this locality.

An instance of the practical value of the use of data obtained in these trap-lights, when correlated with observations made under field conditions during the same period, has already been published. Poos (10), reported the collection of large numbers of adults of *Empoasca fabae* in the trap-lights at Arlington Experiment Farm each year about June 14, at the same time that a large brood of adults of *E. fabae* was observed maturing on oak and hickory, thus indicating the importance of these hosts in the northward migration of this species each season. A further clue was thereby offered toward a satisfactory explanation of the northward migration of *E. fabae* on these hosts, which was substantiated by means of other studies.

Each year, after its first appearance, the number of *Empoasca fabae* invariably increased as the season advanced, but neither the relative number nor the periodic occurrence of the other species remained constant in the trapped material that it was practicable to identify. During the period from approximately

June 15 to September 5, each year, males of *E. fabae* at the trap-lights were so abundant in proportion to all other species that it was not practicable to attempt to determine the relative abundance of the various species from such collections during that period. Likewise, a large collection of *Empoasca*, attracted to the light in the room, was made at the laboratory window the night of August 29, 1932. Of the 319 specimens caught all but one were males, of which 100, selected at random for identification, proved to be *E. fabae*.

Special periods of migration of *Empoasca fabae* to the laboratory window were observed at other times, during which about 97 per cent of the adults collected were males. No evidence was obtained in this way or at the trap-lights which would indicate more or less regular peak periods, explaining the number of generations through which this species passes during each season, as reported by Lawson (7) in Kansas. Six complete generations of *E. fabae* have been reared during a single season at the Arlington Experiment Farm (8). In the greenhouse a strain of this species has been bred continuously for several years without passing through any noticeably quiescent stage (8). These data indicate that definite broods or generations of *E. fabae* can not be distinguished under field conditions where a large variety of favorable host material is present.

The last species to be taken seasonally in the trap-lights was *Empoasca fabae*, November 21, 1934, 2 females and 1 male being collected after an interval of 18 days when, November 4, 1 female and 8 males (all *fabae*) had been taken. However, the continued operation of the lights until December 5 yielded no further specimens of *Empoasca*. This parallels a record of the latest collection in the field at Arlington Experiment Farm, November 21, 1933, when two collectors made 175 sweeps in alfalfa with an insect net and obtained only 6 males and 6 females (no nymphs), the males being identified as *E. fabae*. The fact that *E. fabae* has not been taken in the trap-lights or in collections made in the field at Arlington Experiment Farm prior to May 7 each year, indicates further that this species migrates northward each season.

#### SUMMARY.

Trap-lights yielded a large quantity and a great variety of species of *Empoasca*. Records on the occurrence of uncommon or undescribed species may be obtained in this way, and descriptions of two new species and some new synonymy resulting from the study of trap-light material are given. During the period of greatest abundance the males far outnumber the females in trap-light collections, while in field collections the proportion of sexes is reversed. As in the field, *Empoasca fabae*

is by far the most abundant species and the earliest to appear. The period (May 7 to 15), during which *E. fabae* first appears in the trap-light coincides with the earliest appearance of adults of this species in the field. The occurrence of the first large collections of *E. fabae* in the trap-lights is correlated with the maturing of a large brood of adults of this species on oak and hickory in the vicinity. *Empoasca fabae* is the last species of the genus collected in the trap-lights each season. Collections of *Empoasca* in the trap-lights give further indication that *E. fabae* migrates northward each spring.

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